PSARC Working Paper G86-1. 1986 Assessment for Commercially Exploited Rockfish Stocks in the Strait of Georgia

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PSARC WORKING PAPER G86-1. 1986 ASSESSMENT FOR COMMERCIALLY EXPLOITED ROCKFISH STOCKS IN THE STRAIT OF GEORGIA

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ABSTRACT

Richards, L. J. 1986. PSARC Working Paper G86-1. 1986 assessment for commercially exploited rockfish stocks in the Strait of Georgia. Can. MS Rep. Fish. Aquat. Sci. 1885: 55 p.

Landed catch of rockfish in the British Columbia inshore commercial fishery (minor statistical areas 12-20, 28, 29) increased by almost 600% between 1975 and 1984, from a low of 67 t annually to a 1984 level of 381 t and landed value of nearly one million dollars. Most of the rockfish landings are by handline/troll gear, with smaller amounts by longline and trawl. Handline/troll LPUE (landings per unit effort) decreased 15-23% between 1982 and 1984. This decrease in LPUE is indicative of major decreases in the stock size of rockfish in the Strait of Georgia over the past few years, associated with an increase in targeted fishing effort. At present, there are no restrictions on the Strait of Georgia rockfish catch. It is recommended that a quota, if established, be based on historical handline/troll and longline landings until more comprehensive biological data become available.

RESUME

Richards, L. J. 1986. PSARC Working Paper G86-1. 1986 assessment for commercially exploited rockfish stocks in the Strait of Georgia. Can. MS Rep. Fish. Aquat. Sci. 1885: 55 p.

Les débarquements de scorpènes de la pêche commerciale côtière de la Colombie-Britannique (zones statistiques mineures 12 à 20, 28 et 29) ont augmenté de près de 600 % de 1975 à 1984. Ils sont passés de 67 t, en 1975 à 381 t, en 1984, pour une valeur de près d'un million de dollars. La plus grande partie de ces prises sont faites par les pêcheurs à la ligne ou à la traîne, le reste par les pêcheurs à la palangre ou au chalut. La valeur des débarquements par unité d'effort (DUE) de la pêche à la ligne et à la traîne a diminué de 15 à 23 % entre 1982 et 1984. Cette baisse montre que le stock de scorpènes du détroit de Géorgie a fortement décliné au cours des dernières années suite à une augmentation de l'effort de pêche visant ces espèces. La pêche des scorpènes ne fait actuellement l'objet d'aucune limitation dans le détroit de Géorgie. L'auteur recommande, advenant l'établissement d'un contingent, que celui-ci soit basé sur les débarquements des pêches à la ligne, à la traîne et à la palangre, du moins tant qu'on ne disposera pas de données biologiques plus détaillées.

READ CAREFULLY

1. Reporting of all catches to the Dept of Fisheries and Oceans is the responsibility of the fisherman and a condition of licence renewal
2. Accurate catch reports must include the map number or numbers showing the area in which your fish were caught
3. The statistical areas shown on this map are to be used as a guide only For more exact information refer to the Pacific Fishery Management Area Regulations

● Dept of Fisheries and Oceans Office

——— Statistical areas are divided by red lines

——— Surfline

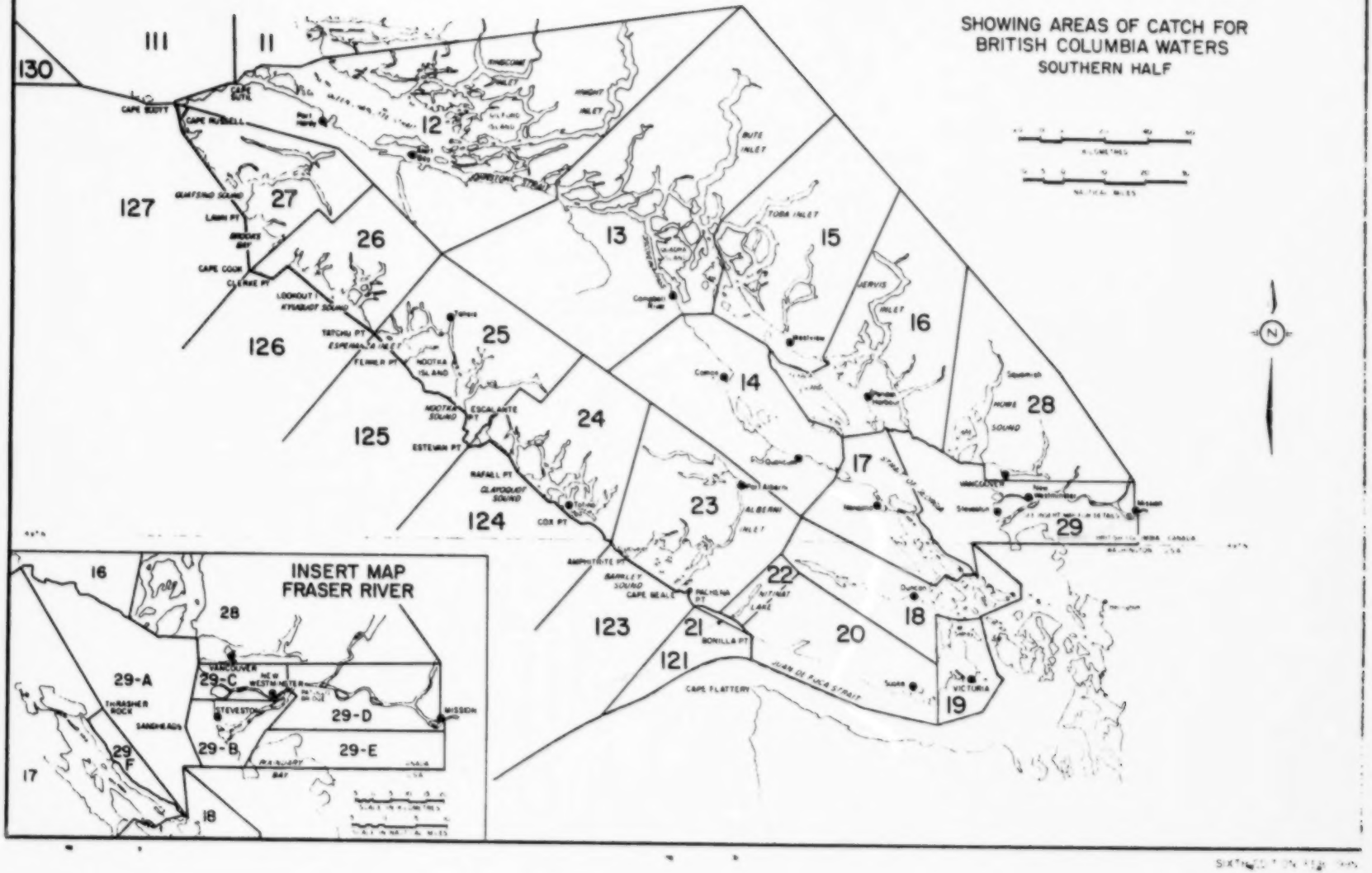
Note All areas revised February 1985

Fisheries and Oceans / Pêches et Océans

Canada

STATISTICAL AREA MAP

SHOWING AREAS OF CATCH FOR BRITISH COLUMBIA WATERS SOUTHERN HALF



INTRODUCTION

Landed catch of rockfish in the British Columbia inshore commercial fishery increased by almost 600% between 1975 and 1984, from a low of about 67 t annually to a current level of 381 t and landed value of one million dollars (Fig. 1, 2). Most of the inshore vessels use handline gear and supply live rockfish to restaurants and retail outlets in Vancouver's Chinatown. At present, there are no restrictions on the commercial catch. Here I present an analysis of the status of inshore rockfish stocks in minor statistical areas 12-20, 28, and 29. The analysis will form the basis for a management plan for these stocks. I consider rockfish biology and data from the commercial fishery only. Analyses of the economic and recreational data bases are to be conducted by South Coast Division.

BIOLOGICAL DATA

In 1984 a program was initiated to obtain biological samples of landed catch from the inshore commercial rockfish fishery. Details of sampling methodology and samples collected between July 1984 and March 1985 are presented in Cass et al. (1986). Five samples of the landed catch from area 13 were collected during this period. Based on combined samples, the landed catch was 85% quillback rockfish (Sebastes maliger) and 15% copper rockfish (S. caurinus), with minor amounts of yelloweye rockfish (S. ruberrimus), yellowtail rockfish (S. flavidus) and kelp greenling (Hexagrammos decagrammus).

In our discussions with fishermen, it appears that the preferred size of landed rockfish is about 0.7 kg (1.5 lb), and they may discard fish that are less than about 0.3 kg. We found significant differences between localities and seasons and with depth in the size of quillback rockfish in our samples. The mean length of quillback rockfish was 32.6±0.2 cm for males and 33.3±0.2 cm for females. Mean weights were 0.70±0.01 kg and 0.81±0.1 kg for males and females respectively. A total of 84% of the males and 75% of the females were mature. Length at 50% maturity was 25 cm for males and 27 cm for females. Analyses for copper rockfish were based on smaller sample sizes than for quillback rockfish. Mean lengths for copper rockfish in our samples were 31.4±0.44 cm for males and 32.4±0.5 cm for females. Mean weights were 0.57±0.02 kg and 0.65±0.03 kg for males and females respectively. Length at 50% maturity was 25 cm for males and 24 cm for females.

To date, ages have been determined for only one of the five samples. These data are presented in Figures 3-5 for copper rockfish and quillback rockfish. Ages in the samples ranged from about 2-40 yr for both species. Copper rockfish appear to have a faster growth rate and are caught at a younger age. The modal age of copper rockfish in the samples was 6-7 yr compared to 13-14 yr for quillback rockfish.

Rockfish bear live young, and most parturition probably occurs between January and April or May. As yet, we have only limited data on parturition timing for the different species of rockfish. There is also geographic variation, with parturition occurring earlier in the southern part of the Strait of Georgia than in the northern part. There is no evidence that rockfish are more or less susceptible to fishing gear during the parturition period.

Species composition of the landed catch depends on depth of fishing (Richards and Cass 1985; Richards et al. 1985). Quillback rockfish and yelloweye rockfish are found predominantly below 40 m and copper rockfish and kelp greenling predominantly above 40 m. The size composition of the landed catch also depends on depth of fishing, as the median size of quillback rockfish and yelloweye rockfish tends to increase with depth (Richards 1986).

LANDING STATISTICS

Rockfish landings by gear type for statistical areas 12-20, 28 and 29 from 1954-85 are presented in Table 1 and Figure 1. Trawl landings are from the Groundfish data files maintained at the Pacific Biological Station. Handline landings and longline landings are from the British Columbia Catch Statistics, Department of Fisheries and Oceans, Annual Reports.

Most of the trawl landings of rockfish have been from areas 18, 19 and 20. In addition, there were significant trawl landings (over 10 t) in the 1950s and 1960s in area 14 and in the late 1960s and early 1970s in area 17. Annual trawl landings of rockfish averaged 98 t between 1954 and 1970. Since 1970 however, trawl landings have decreased to an annual average of 41 t. Longline landings, by contrast, averaged only 13 t annually between 1954 and 1977. They began to increase about 1977, and averaged 52 t annually between 1977 and 1985. Most of the longline landings were in areas 12, 16, 17, 18, 20 and 28, although there are not consistent annual trends in landings in any one area.

Most of the current rockfish landings are by handline/troll. (Unfortunately, handline and troll landings are combined in all of the available statistics.) Handline/troll landings of rockfish were historically less than trawl landings, and averaged 52 t annually between 1954 and 1976 (excluding the erroneous 1969 value). However, handline/troll landings more than doubled between 1977 and 1978, and they have continued to increase. The 1984 value is 7.5 times the 1977 value. Most of the recent landed catch is from area 13, although there have also been significant landings (over 10 t) from areas 12, 15, 16, 17 and 18.

ANALYSES OF CATCH AND EFFORT DATA

The remaining analyses are based on the sales slip data files maintained by the Department of Fisheries and Oceans, Statistics Division. I

had access to the data tapes for 1979-85, although the 1984 data files may have been incomplete and the 1985 data files did not include most records from the latter half of the year. There are some differences between these data and those reported in Table 1, as the sales slip files include gear types such as shrimp trawl that are not reported in the Groundfish data files. For the analyses, I calculated total landed catch of rockfish by all gear types as reported in the sales slip files. I calculated LPUE (landed catch per unit effort) from the sales slip handline/troll data only.

There are several major problems with the sales slip data that could affect the outcome of the analysis. The most severe problem is that an unknown amount of landed catch is not reported. Further, the unknown proportion of the total catch may change from year to year. Hence, the figures for landed catch that follow more correctly represent minimum landed catch. There are also other problems. The sales slip data are not verified by interview and the numbers written on the sales slip are those that are entered into the data base. For example, in some cases the effort reported on the sales slips may refer to days fished and in other cases to the trip length.

Beginning in 1983 the weight of rockfish landed was converted to round weight in the sales slip files. Prior to 1983, weight is reported in the landed form, e.g. dressed, head on or off, round weight, etc. As most rockfish are sold live (round), I did not correct for differences in landed form for this analysis.

One landing was occasionally reported across two or more sales slips. In these cases I chose to use the maximum reported effort for any landing by a vessel on a given day. Sales slips were omitted from the analysis if the effort was listed as zero. This may have occurred if landed catch was combined from two or more statistical areas and all of the effort was assigned to one of the areas.

For the analysis, I initially selected all landing records for a vessel on a given day if a rockfish landing was reported. Further analyses were generally performed by qualification level. I included the landing record in the analysis if the landed rockfish catch was greater than a minimum percentage of the total landed catch by weight. I calculated equivalent effort for each year as the ratio of total landed catch to qualified LPUE. As I found little difference in the time trends of landings and effort using qualification levels of 20%, 40%, 60%, and 80%, most of the analyses are reported for the 20% qualification level only.

LPUE by statistical area and combined over statistical areas for each year of data is given in Table 2. LPUE, total landed catch and equivalent effort are shown for the important statistical areas in Figures 6-8. The general pattern is an increase in LPUE from 1979 to a maximum in 1980-81, followed by a gradual decrease. The decrease in LPUE is associated with an increase in landed catch and in effort. The initial increase in LPUE can be accounted for by an increasing concentration on rockfish as a target species. This is shown in Table 2 by an increase between 1979 and 1983 in the proportion of the total landed catch that is included by the 20% and 40% qualification levels. The decrease probably reflects a decrease in stock size.

The decrease in LPUE between 1982 and 1984 was 15-23%, depending on qualification level. We found LPUE for quillback rockfish in our research fishing program to be proportionally related to stock abundance, as measured by visual observations from a submersible (Richards and Schnute 1986). Hence, a 15-23% decrease in LPUE in our research fishing would indicate a 15-23% decrease in stock size. The relationship between commercial handline/troll LPUE and stock size is less clear, however. I expect that commercial LPUE is a relatively insensitive stock abundance index and underestimates changes in stock size. If this is true, then major decreases in the size of rockfish stocks have occurred in the Strait of Georgia over the past few years.

LPUE trends for statistical area 13 are most representative of the annual changes in LPUE, as most of the landed catch has been from this area. With the exception of area 12, LPUE in area 13 tends to be higher than in the other areas where there have been significant landings. The decreases in LPUE in areas 15, 16 and 18 have in fact been greater than in area 13. In areas 12 and 17, LPUE appears to have increased in the last few years, perhaps because of an increase in effort targeted on rockfish. The high LPUE in area 12 probably results from the recent expansion of the fishery into this area and the exploitation of previously unfished rockfish stocks. High and low values of LPUE in other statistical areas can be accounted for by small landings.

Changes in LPUE, landed catch and effort are more clearly demonstrated by statistical area in Figures 6-8. In general, trends in landed catch and in effort are similar within a statistical area. LPUE is shown for a range of qualification levels, including all the data and records selected by 20%, 40%, 60% and 80% qualification levels. With the exception of area 12, qualification levels of 20-80% lead to similar trends in LPUE. For area 12, the 20% qualification level does not exhibit the increase in LPUE in 1981 that is apparent using higher qualification levels. For all the areas illustrated, differences in the value of LPUE obtained from using different qualification levels have decreased in the last few years. This is another indication of an increase in directed effort on rockfish.

One way in which LPUE may be compared among statistical areas is in proportion to the relative sizes of the areas. We determined the relative sizes from the length of fishable shoreline (measured at the 20 fath depth contour) in each area (Table 3). The 20 fath depth contour approximates the median depth of fishing in the commercial handline fishery in the Strait of Georgia. A total of 12 charts were used for this procedure with scales from 1:73000 to 1:110000. The total length of the contour was determined within each statistical area, including reefs and shoals. The length of the contour for areas deemed "unsuitable" was then determined. This occurred, for example, if the area was designated on the chart as sand or mud or if it was an estuary. This "unsuitable" length was subtracted from the total length to estimate the length of "suitable" rockfish habitat. Because of the amount of unsuitable habitat in area 29, only the length of "suitable" habitat was determined for that area.

LPUE based on this analysis is given in Table 4. In general, the lowest values for LPUE, relative to the size of the statistical area, were for

the largest statistical areas, that is, areas 12, 13 and 16. In all three of the areas, there are large regions where little fishing occurs, such as at the head of major fjords. The lowest LPUE is for area 12, the largest area. Areas 13 and 16 are similar in size and have similar low relative LPUE values. Values are higher for other statistical areas.

FLEET PATTERNS

Table 5 describes the patterns of vessel entry and exit for the rockfish handline fishery. The number of vessels reporting 20% qualified handline/troll landings of rockfish has decreased from the 1979 total of 484 vessels to the 1984 total of 327 vessels. There is a high vessel turnover. Only 30-40% of the vessels remain in the fishery after one year. The largest fleet of vessels is in area 13. In 1984, 42% of the rockfish handline vessels in the Strait of Georgia reported 20% qualified landings from area 13. Area 12 had the second largest fleet in 1984 and this area is becoming increasingly important.

RECOMMENDATIONS

It appears that major decreases in the size of rockfish stocks have occurred in the Strait of Georgia over the past few years. In general, such decreases could be accounted for either by recruitment or by overfishing. However, as rockfish are long-lived and recruit to the fishery over several years, recruitment failure is not a sufficient explanation for the observed decrease. The most likely explanation for this decrease is overfishing.

Fisheries on long-lived species are often characterized by a period of high catches followed by a rapid decline in catch, associated with a decline in stock size (Leaman and Beamish 1984). This is the pattern that was observed in the Queen Charlotte Sound Pacific ocean perch (Sebastes alutus) fishery, and consequently, long-term (on the order of decades) rehabilitative measures became necessary (Archibald et al. 1983). At present, we have insufficient biological information for the inshore commercial rockfish fishery on which to base a more complete stock assessment. We are also lacking a time series of landed catch and effort data for the recreational fishery. If no management action is taken, however, the probable effect will be to reduce rockfish stocks in the Strait of Georgia to levels at which they can no longer be economically fished. The fishery will then be re-directed to more remote areas (area 12, Prince Rupert, West Coast Vancouver Island). Anecdotal reports suggest that local depletion has already occurred in some areas.

The decreases in LPUE began after 1982 when landed catch from the handline/troll and longline fisheries totalled 278 t. If the decrease in LPUE is due to overfishing, then a value of 278 t must be too high. Historically,

that is prior to 1977, landed catch from the handline/troll and longline fisheries averaged 65 t annually. Hence, a sustainable value for landed catch in this fishery is greater than 65 t annually (at pre-1977 stock levels), but much less than 278 t annually. As the 1986 stock levels are considerably reduced from historical levels however, a landed catch as low as 65 t may no longer be sustainable. The chosen quota for the Strait of Georgia should depend on whether the management policy is to slow the current decline (quota near 250 t), to maintain stocks at current levels (quota between 100 and 200 t), or to rehabilitate stocks (quota less than 100 t).

I have excluded trawl landings from the analysis as most of the current landings of rockfish are from area 13, and annual trawl landings of rockfish from area 13 have always been low. The maximum landed catch in the area 13 trawl fishery was 5 t in 1964. Conversely, the high trawl landings in the late 1950s and early 1960s were mainly from area 20, and the maximum landed catch in the area 20 handline/troll fishery was 3.2 t in 1958. Historical landed catch by all gear types averaged 163 t annually. Landed catch by all gear types in 1982 totalled 327 t. If the trawl data are included in the analysis, then the quota for the Strait of Georgia should be between 150 t and 300 t.

A problem with setting one quota for the Strait of Georgia is that some statistical areas, such as area 13, are likely to receive heavier fishing pressure than other areas. If commercial fishing occurs over a wide geographic region, then the quota could be closer to the upper end of the suggested range. However, if it appears that most of the quota will be taken from area 13, then the quota should be based on historical landings from area 13, rather than from historical landings combined across all statistical areas in the Strait of Georgia. Following this method, quotas from individual statistical areas could be derived from historical landings in those areas.

An alternative method is to set the quota for each statistical area in proportion to the relative size of that area (from Table 3). In particular, area 12, the largest statistical area, is still relatively unexploited and can sustain a heavier fishing pressure than indicated by historical landings from that area. I have shown in Table 4 that this method is inappropriate when applied to all statistical areas in the Strait of Georgia, as it tends to overestimate the stock sizes available in the largest areas: 12, 13 and 16. However, the best estimate for the quota for area 12 is twice the historical landings from area 13, as area 12 is approximately twice the size of area 13.

Once the size of the quota is established, a second problem is to determine the time of year that the fishery should take place. For example, a 100 t quota could be taken within a few months. As the most lucrative market is for live fish, it would be advantageous to prolong the fishery as much as possible. The best timing for a closure may be during the period of parturition, between about January and April, as rockfish with eyed larvae are less desirable on the market.

This analysis has been based on landed catch and effort for the commercial fishery only. The 1985 recreational catch of rockfish from the creel survey in areas 13-19, 28, and 29 was 134,005 pieces (T. Shardlow and

T. Hoyt, unpub. data), or 72 t, based on mean weights from our research work (Richards and Cass 1985). This is approximately 18% of the combined recreational and commercial landed rockfish catch from these areas. Most of the recreational catch was taken from areas 16, 17, and 19, rather than from area 13 as in the commercial catch. The recreational fishery also removed higher proportions of copper rockfish and yelloweye rockfish than the commercial fishery. Hence, these two fisheries tend to be distinct, and it may be possible to manage them independently.

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Table 1. Landed catch of rockfish (t) by statistical area and combined over statistical areas 12-20, 28, and 29 for 1954-1985. (1985 data are provisional). Trawl landings are from the Groundfish data files. Longline landings and handline/troll landings are from the British Columbia Catch Statistics.

a) Trawl landings

Year	Statistical Area											
	12	13	14	15	16	17	18	19	20	28	29	TOTAL
54	5.0	0.3	29.5	0.0	0.0	7.7	11.4	0.7	60.7	0.0	4.8	120.1
55	1.5	0.1	12.1	0.0	0.1	8.4	87.1	1.0	19.5	0.0	0.8	130.5
56	5.6	0.6	15.3	0.0	0.0	9.1	4.3	17.2	18.0	0.0	1.4	71.6
57	0.9	0.3	14.5	0.2	0.0	8.5	4.5	0.5	1.2	0.1	2.6	33.3
58	1.2	0.8	8.0	0.0	0.0	9.9	2.0	3.0	27.2	0.0	1.2	53.3
59	1.0	0.9	6.2	0.0	0.0	8.3	16.1	48.3	77.5	0.0	0.7	159.0
60	0.8	0.3	7.2	0.0	0.1	6.1	8.3	7.6	144.8	0.0	0.7	175.7
61	1.6	0.1	11.1	0.2	0.3	7.7	15.5	6.0	61.0	0.0	0.8	104.1
62	2.4	0.8	9.0	0.0	0.5	9.1	12.6	0.3	56.9	0.0	1.0	92.7
63	0.1	1.5	10.5	0.0	0.0	7.4	14.6	0.9	17.2	0.0	0.4	52.8
64	0.3	5.0	5.7	0.0	0.0	8.9	20.1	4.5	71.4	0.0	1.2	117.1
65	0.5	1.1	8.3	0.0	0.0	2.1	9.6	4.0	38.6	0.0	1.0	65.3
66	2.2	0.0	7.5	0.0	0.0	1.7	7.8	0.8	118.8	0.0	0.0	138.8
67	2.3	1.2	4.5	0.0	0.0	2.9	5.2	0.7	31.8	0.0	0.1	48.8
68	1.4	0.0	6.3	0.0	0.0	21.7	4.2	0.9	64.4	0.0	0.1	98.9
69	0.8	1.2	9.1	0.0	0.0	4.4	5.4	2.4	75.5	0.0	0.3	99.0
70	0.0	0.0	5.9	0.0	0.0	12.5	7.8	0.1	75.9	0.0	0.2	102.4
71	0.1	0.1	6.4	0.0	0.0	9.1	7.0	0.4	10.5	0.0	0.6	34.2
72	0.0	0.0	6.1	0.0	0.0	7.4	2.9	0.1	29.1	0.0	0.0	45.6
73	0.5	1.9	3.1	0.0	0.0	12.1	2.9	0.0	3.5	0.0	0.1	24.0
74	0.0	0.2	5.3	0.0	0.0	5.6	5.7	0.1	4.1	0.0	0.6	21.7
75	0.1	1.8	4.0	0.0	0.0	2.3	7.6	2.4	10.9	0.0	0.0	29.1
76	0.2	1.0	3.3	0.0	0.0	2.0	9.1	1.1	14.3	0.0	0.0	31.0
77	1.2	0.8	5.2	0.0	0.0	2.6	7.9	2.0	10.5	0.0	0.0	30.1
78	9.8	0.4	5.6	0.0	0.0	1.7	12.3	5.7	16.5	0.0	0.1	52.0
79	0.4	0.0	3.8	0.0	0.0	3.6	15.7	17.5	82.9	0.0	0.4	124.2
80	0.1	0.1	1.2	0.0	0.0	5.2	6.4	6.1	20.7	0.0	0.1	39.8
81	0.6	0.0	1.8	0.0	0.0	2.6	11.0	15.8	17.9	0.0	1.5	51.1
82	0.0	0.1	2.9	0.0	0.1	5.2	9.7	11.5	19.2	0.0	0.2	48.7
83	2.7	0.1	0.9	0.0	0.0	3.5	11.1	4.2	4.8	0.0	0.1	27.4
84	0.1	0.0	1.1	0.0	0.0	1.8	15.4	7.7	12.3	0.0	0.4	38.8
85	0.2	0.0	1.0	0.0	0.0	1.9	5.9	5.7	7.9	0.0	0.1	22.6

b) longline landings

Year	Statistical Area											
	12	13	14	15	16	17	18	19	20	28	29	TOTAL
54	6.3	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	7.2
55	8.2	0.0	0.0	0.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	11.5
56	6.5	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	7.8
57	5.7	0.0	0.0	0.3	1.0	0.5	0.0	0.0	0.0	0.0	0.0	7.5
58	5.4	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	6.4
59	7.6	0.1	0.6	1.3	0.4	5.1	0.1	0.0	0.0	0.0	0.0	15.1
60	6.6	0.2	0.5	1.0	0.9	2.2	0.1	0.1	0.0	0.0	0.0	11.7
61	7.0	0.3	0.1	0.2	0.2	2.4	0.4	0.0	0.0	0.0	0.0	10.7
62	5.9	0.6	0.0	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.0	7.3
63	11.2	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	11.7
64	6.2	0.1	0.0	0.0	4.7	0.0	0.0	0.0	0.4	0.0	0.0	11.4
65	7.8	0.0	0.0	0.0	5.0	0.3	0.0	0.0	0.0	0.0	0.0	13.1
66	3.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.1	0.0	6.1
67	7.2	0.0	0.0	0.0	2.9	0.1	0.0	0.0	0.1	0.0	0.0	10.3
68	8.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	9.1
69	7.7	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	9.2
70	15.2	1.1	0.0	0.1	0.0	0.4	0.1	0.0	0.5	0.0	0.0	17.7
71	16.9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	17.1
72	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	22.4
73	27.2	3.2	0.0	2.7	9.5	1.4	0.0	0.0	0.0	12.3	0.0	56.3
74	1.8	0.0	0.0	0.0	0.5	5.4	0.5	0.0	0.0	0.8	0.0	9.0
75	2.7	0.5	0.0	1.8	0.5	1.4	0.0	0.0	0.0	1.2	0.0	8.0
76	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	10.5
77	30.4	0.0	0.5	8.6	2.7	2.3	0.0	0.0	0.0	13.8	0.5	58.7
78	7.0	0.0	1.0	6.0	15.0	18.0	5.0	1.0	1.0	1.0	2.0	57.0
79	23.0	6.0	4.0	7.0	18.0	22.0	8.0	1.0	0.0	1.0	4.0	94.0
80	9.0	2.0	4.0	4.0	11.0	7.0	18.0	1.0	1.0	2.0	0.0	59.0
81	8.7	2.6	6.0	2.2	2.7	8.8	17.1	0.1	0.0	0.4	0.4	49.0
82	6.5	2.3	3.0	1.5	2.2	2.0	9.5	0.0	0.0	0.2	0.7	27.9
83	3.2	1.8	0.2	3.0	1.4	6.8	11.5	0.2	0.0	0.0	0.0	28.1
84	9.1	1.9	1.3	0.3	0.2	20.1	7.5	0.2	0.0	0.0	0.5	41.1

c) handline/troll landings

Year	Statistical Area											
	12	13	14	15	16	17	18	19	20	28	29	TOTAL
54	0.0	6.8	0.8	0.6	5.9	15.1	6.1	0.0	0.0	0.4	0.0	35.8
55	0.0	3.5	0.6	1.1	2.9	16.1	4.2	0.2	0.0	0.1	0.0	28.7
56	0.3	2.0	0.2	1.0	5.0	17.7	5.5	0.1	0.1	0.0	0.2	32.1
57	0.0	6.1	2.5	2.5	13.5	25.5	7.0	6.5	0.0	0.1	1.1	64.9
58	2.6	10.8	9.8	5.5	14.9	29.3	15.8	6.3	3.2	0.0	2.0	100.2
59	5.6	16.3	8.7	9.4	10.5	31.3	3.9	3.9	0.5	0.1	0.7	91.0
60	3.5	19.9	4.3	10.8	10.3	17.6	3.4	3.1	0.9	0.4	0.1	74.3
61	3.4	16.6	6.4	2.5	4.7	13.8	2.8	1.4	0.6	0.1	1.5	53.8
52	46.9	14.5	4.7	5.8	2.9	19.1	2.4	2.5	0.6	0.2	0.5	100.2
63	27.9	7.8	3.7	1.6	5.7	16.4	2.8	0.9	0.2	0.0	0.1	67.1
64	4.9	4.5	2.1	0.9	8.1	8.8	2.8	1.1	0.3	0.0	0.1	33.7
65	2.4	3.5	2.1	0.1	5.3	9.0	3.3	0.4	0.1	0.0	0.3	26.5
66	1.2	3.6	3.8	0.5	10.1	4.1	4.1	0.2	0.1	0.0	0.0	27.7
67	2.7	7.6	5.9	3.4	13.8	6.2	1.9	0.1	0.0	0.0	0.0	41.6
68	3.8	8.2	5.0	1.0	17.9	10.3	1.4	0.2	0.1	0.0	0.0	47.9
69	17.6	12.0*	3.8	3.5	15.2	8.8	4.2	0.3	0.9	0.0	0.1	66.4
70	8.6	15.8	4.0	4.9	9.8	15.7	1.4	0.6	0.3	0.0	0.0	61.2
71	11.7	9.4	2.7	5.1	6.6	12.2	1.0	0.3	0.0	0.0	0.0	49.0
72	10.9	14.1	5.0	4.5	11.8	12.2	0.9	0.5	0.0	0.0	0.0	59.9
73	3.6	8.2	2.7	4.5	5.4	9.1	1.4	0.0	0.0	0.0	0.0	34.9
74	6.8	7.3	3.2	8.2	2.3	6.8	2.3	0.0	0.0	0.0	0.0	36.7
75	3.2	5.4	2.3	4.5	1.4	7.7	4.5	0.5	0.0	0.5	0.0	29.9
76	3.6	10.4	5.0	7.7	2.7	7.3	2.7	0.0	0.9	0.0	0.0	40.4
77	25.4	17.7	8.6	7.3	2.7	8.6	15.0	2.7	0.9	0.0	0.5	89.4
78	14.0	30.0	6.0	9.0	4.0	11.0	27.0	4.0	0.0	0.0	1.0	106.0
79	17.0	57.0	8.0	9.0	4.0	15.0	38.0	4.0	1.0	1.0	1.0	155.0
80	18.0	41.0	6.0	8.0	9.0	13.0	17.0	4.0	1.0	1.0	0.0	118.0
81	12.0	53.0	6.0	25.0	27.0	12.0	23.0	3.0	0.0	0.0	1.0	162.0
82	15.0	104.0	6.0	73.0	32.0	8.0	9.0	2.0	0.0	0.0	1.0	250.0
83	5.2	184.8	7.1	8.3	27.0	7.4	4.2	1.6	0.2	0.6	0.3	246.7
84	23.6	196.1	2.0	13.0	22.6	17.9	16.1	7.5	2.0	0.2	0.9	301.5

*This figure is mean of the 1968 and 1970 values. The published figure of 332.4 t is obviously an error.

Table 2. Qualified handline LPUE (kg/day) by statistical area, LPUE combined over statistical areas, total weight (t) of rockfish landings reported on sales slips by all gear types, the proportion of the total landed catch that meets the specified qualification level and equivalent effort (days). Equivalent effort is calculated from the ratio of total landed catch to combined LPUE.

a) 20% qualified LPUE

	LPUE by statistical area														
Year	12	13	14	15	16	17	18	19	20	28	29	LPUE	Wt	Prop	Effort
79	38.0	42.6	15.5	25.1	35.1	24.7	56.0	21.8	19.0	64.3	14.9	37.2	282	0.47	7566
80	40.7	37.2	13.9	44.8	30.7	23.0	29.7	24.5	26.1	18.6	4.6	30.3	227	0.45	7490
81	45.2	44.7	21.7	93.1	52.3	26.5	47.1	20.6	17.1	18.2	25.5	44.2	266	0.55	6023
82	48.6	52.8	14.7	67.9	42.6	22.9	34.5	16.5	15.3	15.6	23.8	48.6	325	0.74	6676
83	43.4	47.7	45.4	52.8	35.3	33.6	15.7	13.2	31.0	65.0	69.4	43.5	331	0.79	7600
84	59.4	44.5	27.1	40.0	33.7	40.4	34.7	16.8	58.9	9.4	9.5	41.1	392	0.77	9528

b) 40% qualified LPUE

	LPUE by statistical area														
Year	12	13	14	15	16	17	18	19	20	28	29	LPUE	Wt	Prop	Effort
79	42.7	51.1	23.9	29.3	33.0	29.8	59.5	23.8	17.4	64.3	16.5	44.3	282	0.43	6359
80	42.8	44.2	16.1	53.9	32.9	28.0	33.1	30.4	25.5	20.7	4.9	34.9	227	0.42	6497
81	64.7	50.6	25.9	106.	52.7	30.0	49.9	20.0	18.0	18.2	25.5	49.5	266	0.53	5378
82	60.7	55.5	25.0	69.3	44.0	26.0	35.9	21.1	15.3	16.5	23.9	53.1	325	0.71	6114
83	46.0	48.2	56.7	67.2	35.1	39.5	16.4	11.4	-	65.0	74.9	45.0	331	0.78	7354
84	59.9	44.8	33.5	40.9	33.8	41.8	34.8	17.2	21.1	9.4	9.5	41.5	392	0.76	9451

Table 3. The length of fishable shoreline (km), measured at the 20 fath depth contour, for each statistical area, and the relative length of shoreline in each area in relation to the total length of shoreline for areas 12-20, 28 and 29.

Area	Length	Proportion
12	1967.1	0.376
13	837.4	0.160
14	156.7	0.030
15	546.2	0.104
16	666.3	0.127
17	399.1	0.076
18	273.2	0.052
19	166.8	0.032
20	109.2	0.021
28	63.8	0.012
29	50.7	0.010

Table 4. Qualified handline LPUE ($kg \cdot day^{-1} \cdot km^{-1}$) by statistical area. Distances are based on the data in Table 3.

a) 20% qualified LPUE

	Statistical area										
Year	12	13	14	15	16	17	18	19	20	28	29
79	0.019	0.051	0.099	0.046	0.053	0.062	0.205	0.131	0.174	1.008	0.293
80	0.021	0.044	0.089	0.082	0.046	0.058	0.109	0.147	0.239	0.291	0.091
81	0.023	0.053	0.138	0.170	0.078	0.066	0.172	0.123	0.157	0.285	0.502
82	0.025	0.063	0.094	0.124	0.064	0.057	0.126	0.099	0.140	0.245	0.469
83	0.022	0.057	0.290	0.097	0.053	0.084	0.058	0.079	0.284	1.019	1.369
84	0.030	0.053	0.173	0.073	0.051	0.101	0.127	0.101	0.540	0.147	0.187

a) 40% qualified LPUE

	Statistical area										
Year	12	13	14	15	16	17	18	19	20	28	29
79	0.022	0.061	0.152	0.054	0.050	0.075	0.218	0.143	0.160	1.008	0.326
80	0.022	0.053	0.103	0.099	0.049	0.070	0.121	0.182	0.233	0.325	0.096
81	0.033	0.060	0.165	0.194	0.079	0.075	0.183	0.120	0.165	0.285	0.502
82	0.031	0.066	0.159	0.127	0.066	0.065	0.132	0.127	0.140	0.258	0.471
83	0.023	0.058	0.362	0.123	0.053	0.099	0.060	0.068	-	1.019	1.477
84	0.030	0.053	0.214	0.075	0.051	0.105	0.127	0.103	0.193	0.147	0.187

Table 5. The number of vessels that reported 20% qualified handline landings of rockfish between 1979 and 1985 by year of entry into the fishery. Each row of the table gives the number of vessels that first entered the fishery in the year specified by the row headings, and reported landings in years specifed by the column headings. The first table includes data for all areas (12-20, 28, 29) and the following tables are by statistical area. (Note: 1979 is the first year for which data were available. 1985 data are incomplete.)

Year of entry	areas 12-20, 28, 29 — year of landings						
	79	80	81	82	83	84	85
79	484	189	128	128	86	70	43
80	-	237	71	66	38	24	19
81	-	-	205	62	39	34	11
82	-	-	-	176	50	39	22
83	-	-	-	-	115	45	20
84	-	-	-	-	-	115	37
85	-	-	-	-	-	-	54
Total	484	426	404	432	328	327	206

Year of entry	area 12 — year of landings						
	79	80	81	82	83	84	85
79	56	15	4	1	2	0	1
80	-	23	3	4	1	0	0
81	-	-	28	4	3	2	1
82	-	-	-	40	5	4	8
83	-	-	-	-	26	9	4
84	-	-	-	-	-	47	7
85	-	-	-	-	-	-	29
Total	56	38	35	49	37	62	50

Table 5 (cont'd)

Year of entry	area 13 — year of landings						
	79	80	81	82	83	84	85
79	173	69	53	43	33	26	11
80	-	68	21	18	13	7	5
81	-	-	81	24	17	14	5
82	-	-	-	90	20	21	10
83	-	-	-	-	68	30	11
84	-	-	-	-	-	39	14
85	-	-	-	-	-	-	23
Total	173	137	155	175	151	137	79

Year of entry	area 14 — year of landings						
	79	80	81	82	83	84	85
79	75	19	14	18	12	1	2
80	-	30	3	5	1	1	1
81	-	-	28	6	2	0	0
82	-	-	-	43	3	0	1
83	-	-	-	-	12	1	0
84	-	-	-	-	-	7	1
85	-	-	-	-	-	-	11
Total	75	49	45	72	30	10	16

Year of entry	area 15 — year of landings						
	79	80	81	82	83	84	85
79	62	13	9	9	4	6	3
80	-	26	5	4	1	1	0
81	-	-	34	13	5	4	4
82	-	-	-	63	5	2	0
83	-	-	-	-	9	2	1
84	-	-	-	-	-	11	1
85	-	-	-	-	-	-	10
Total	62	39	48	89	24	26	19

Table 5 (cont'd)

Year of entry	area 16 — year of landings						
	79	80	81	82	83	84	85
79	29	6	5	7	4	4	3
80	-	32	8	2	3	1	0
81	-	-	38	16	10	9	2
82	-	-	-	43	11	12	5
83	-	-	-	-	23	9	3
84	-	-	-	-	-	16	7
85	-	-	-	-	-	-	7
Total	29	38	51	68	51	51	27

Year of entry	area 17 — year of landings						
	79	80	81	82	83	84	85
79	83	27	9	6	7	5	3
80	-	64	7	4	0	2	3
81	-	-	35	5	4	0	2
82	-	-	-	35	7	6	1
83	-	-	-	-	19	4	2
84	-	-	-	-	-	21	6
85	-	-	-	-	-	-	15
Total	83	91	51	50	37	38	32

Year of entry	area 18 — year of landings						
	79	80	81	82	83	84	85
79	48	17	6	7	5	1	2
80	-	36	7	3	3	2	2
81	-	-	27	4	1	2	0
82	-	-	-	13	3	2	0
83	-	-	-	-	15	2	0
84	-	-	-	-	-	25	6
85	-	-	-	-	-	-	9
Total	48	53	40	27	27	34	19

Table 5 (cont'd)

Year of entry	area 19 — year of landings						
	79	80	81	82	83	84	85
79	19	8	4	4	1	1	1
80	-	11	4	2	1	2	2
81	-	-	20	5	3	2	2
82	-	-	-	9	0	1	0
83	-	-	-	-	6	3	0
84	-	-	-	-	-	19	3
85	-	-	-	-	-	-	3
Total	19	19	28	20	11	28	11

Year of entry	area 20 — year of landings						
	79	80	81	82	83	84	85
79	12	3	1	0	0	0	0
80	-	5	1	0	1	0	0
81	-	-	6	0	0	0	0
82	-	-	-	2	1	0	0
83	-	-	-	-	1	1	0
84	-	-	-	-	-	6	1
85	-	-	-	-	-	-	3
Total	12	8	8	2	3	7	4

Year of entry	area 28 — year of landings						
	79	80	81	82	83	84	85
79	5	1	0	0	1	0	0
80	-	6	0	1	0	0	0
81	-	-	3	0	0	0	0
82	-	-	-	5	0	1	0
83	-	-	-	-	3	1	1
84	-	-	-	-	-	2	0
85	-	-	-	-	-	-	0
Total	5	7	3	6	4	4	1

Table 5 (cont'd)

Year of entry	area 29 — year of landings						
	79	80	81	82	83	84	85
79	10	1	1	1	0	0	0
80	-	8	0	0	0	0	0
81	-	-	11	3	0	0	0
82	-	-	-	8	0	1	0
83	-	-	-	-	5	0	0
84	-	-	-	-	-	2	0
85	-	-	-	-	-	-	3
Total	10	9	12	12	5	3	3

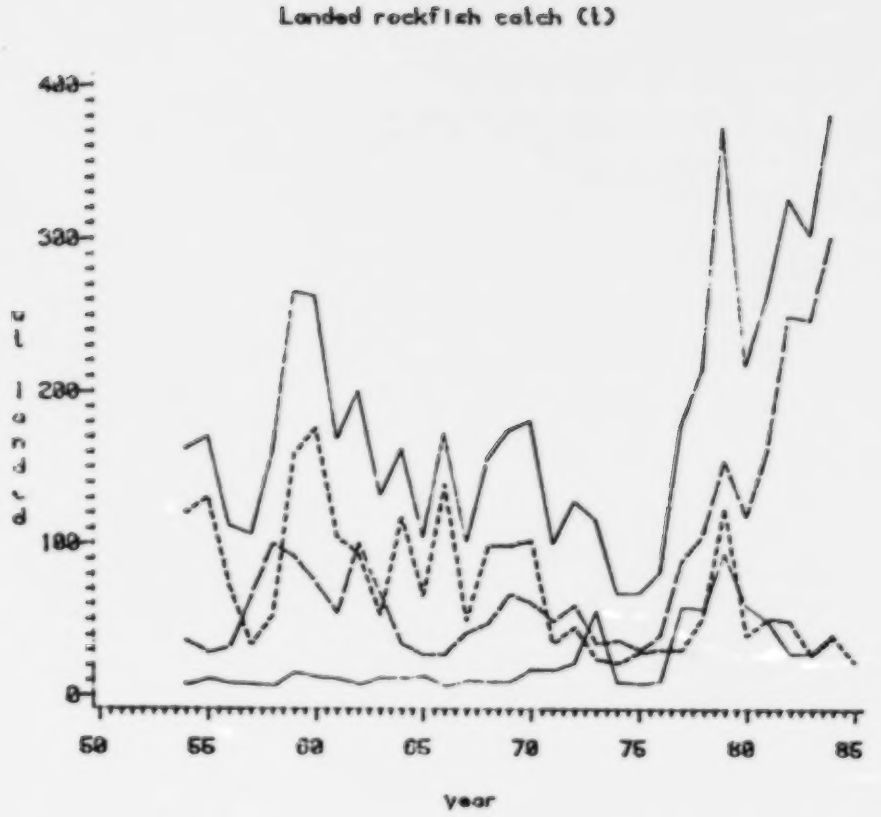

Fig. 1. Total rockfish landings (t) by trawl (dotted line), longline (bottom solid line), and handline/troll (dashed line), and combined landings (top line) for statistical areas 12-20, 28, and 29. Trawl landings are from the Groundfish data files. Handline/troll landings and longline landings are from the British Columbia Catch Statistics.

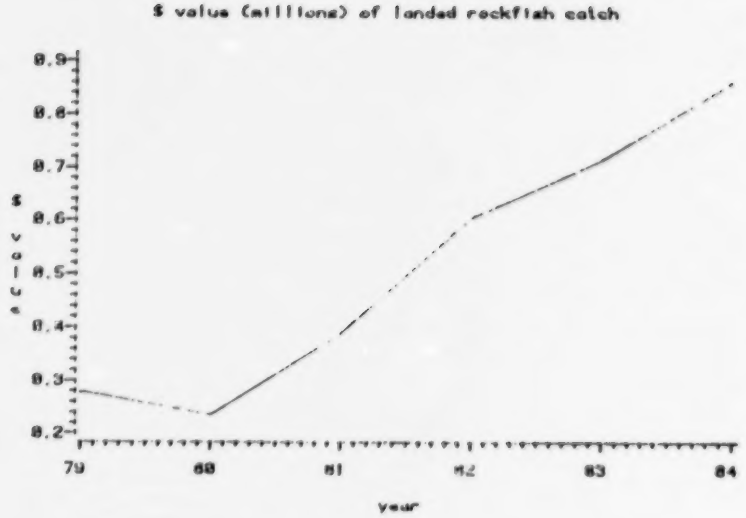

Fig. 2. Dollar value (millions) of the landed rockfish catch by all gear types in areas 12-20, 28, and 29, as reported by the sales slip files.

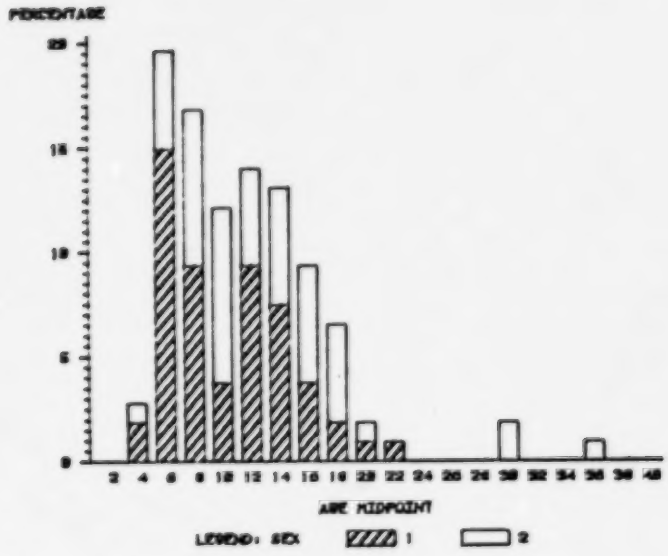

Fig. 3a. Age distributions by sex for copper rockfish (n=102) in samples collected during July 1984 from the commercial rockfish handline fishery in the Campbell River area. Ages shown are the upper limits of 2-yr age-classes. Male = 1; Female = 2.

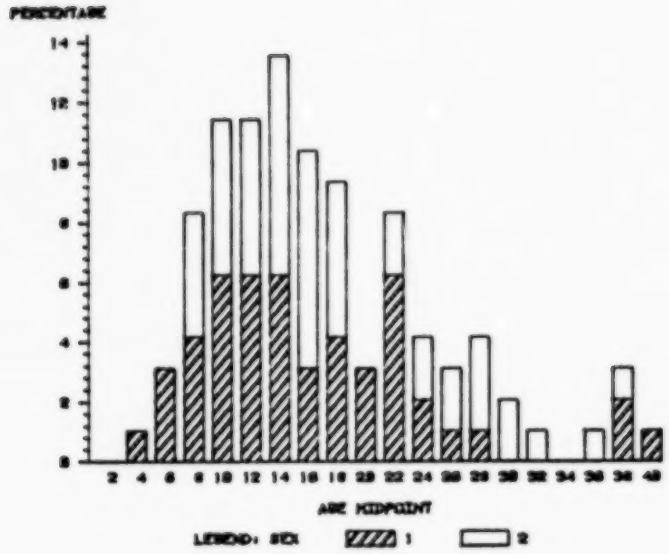

Fig. 3b. Age distributions by sex for quillback rockfish (n=94) in samples collected during July 1984 from the commercial rockfish handline fishery in the Campbell River area. Ages shown are the upper limits of 2-yr age-classes. Male = 1; Female = 2.

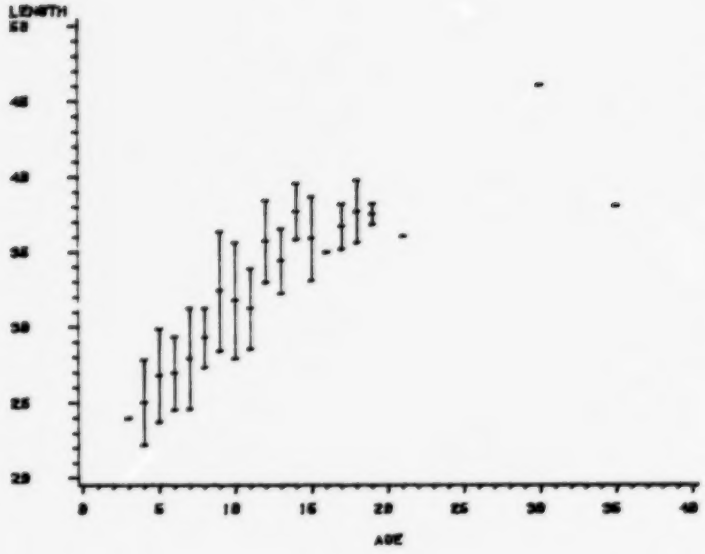

Fig. 4a. Relationship between mean length (cm) and age for combined sexes of copper rockfish (n=107) in samples collected during July 1984 from the commercial handline fishery in the Campbell River area. Bars represent one standard deviation.

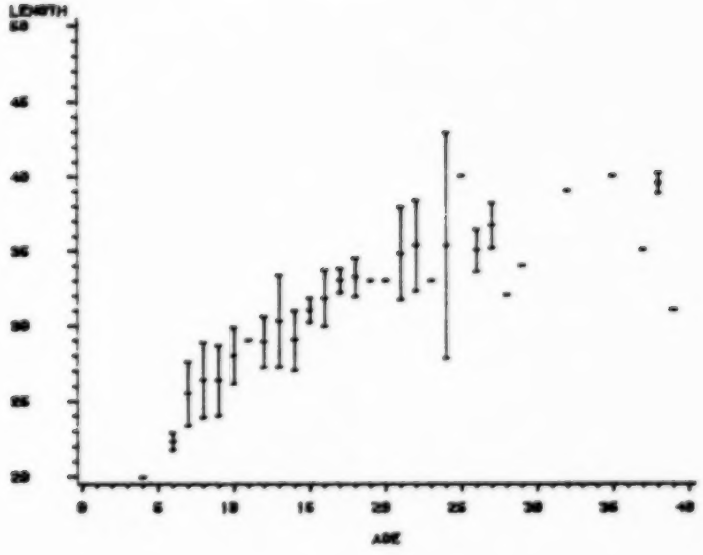

Fig. 4b. Relationship between mean length (cm) and age for combined sexes of quillback rockfish (n=96) in samples collected during July 1984 from the commercial handline fishery in Campbell River area. Bars represent one standard deviation.

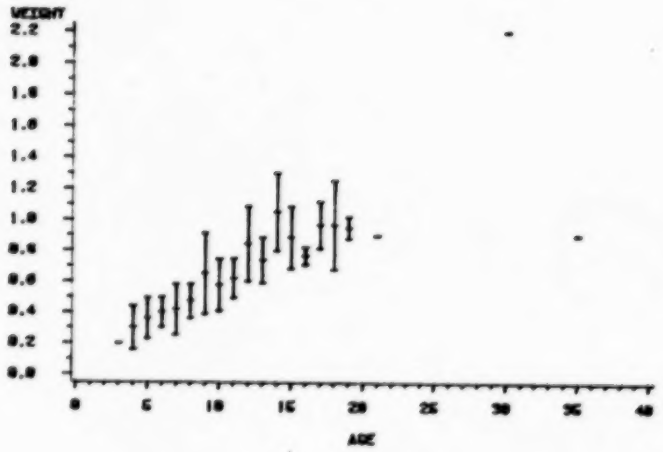

Fig. 5a. Relationship between mean weight (kg) and age for combined sexes of copper rockfish (n=107) in samples collected during July 1984 from the commercial handline fishery in the Campbell River area. Bars represent one standard deviation.

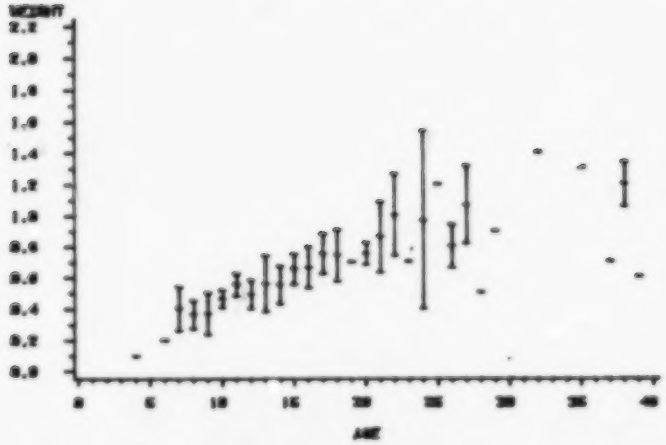

Fig. 5b. Relationship between mean weight (kg) and age for combined sexes of quillback rockfish (n=96) in samples collected during July 1984 from the commercial handline fishery in the Campbell River area. Bars represent one standard deviation.

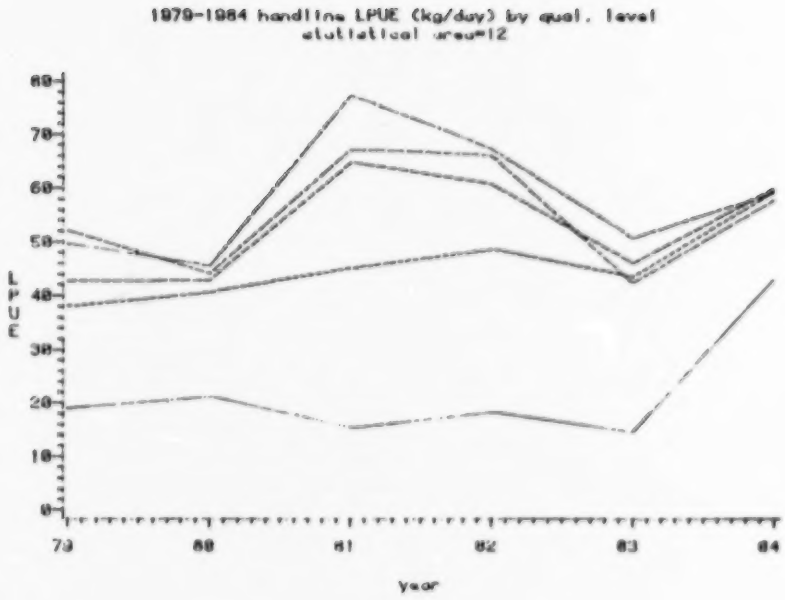

Fig. 6a-6f. LPUE qualification level for handline/troll landings of rockfish in statistical areas 12, 13, 15, 16, 17, and 18 as reported in the sales slip files from 1979 to 1984. The lower solid line is LPUE based on all data. The other lines are for 20%, 40%, 60%, and 80% qualified LPUE, from bottom to top respectively.

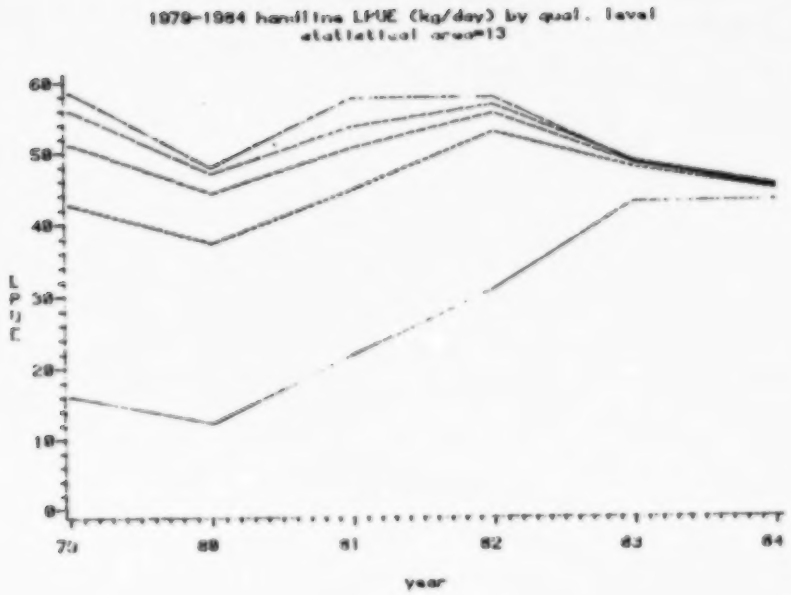
1979-1984 handline LPUE (kg/day) by qual. level
statistical area=13
60
50
40
30
20
10
0
LPUE
79
80
81
82
83
84
year

Fig. 6b.

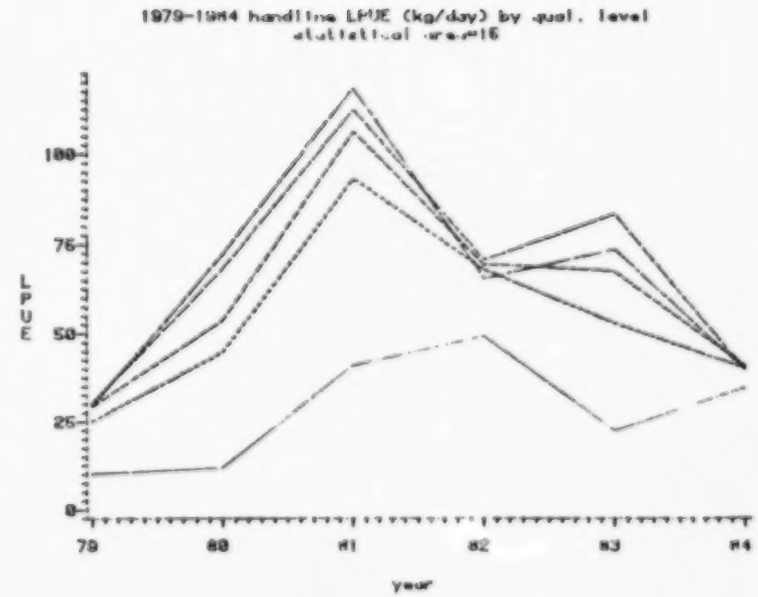
1979-1984 handline LPUE (kg/day) by qual. level
statistical area=16
100
75
50
25
0
LPUE
79
80
81
82
83
84
year

Fig. 6c.

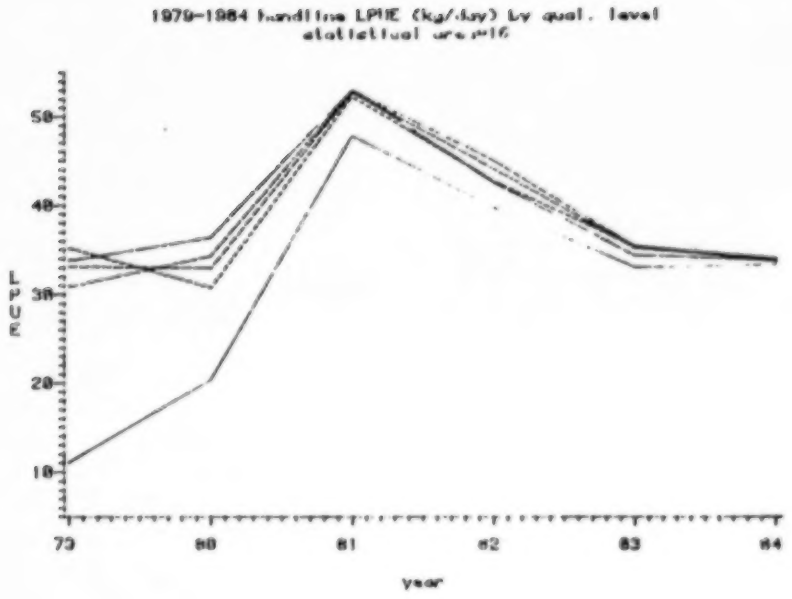
1979-1984 handline LPUE (kg/day) by qual. level
statistical area=16
LPUE
50
40
30
20
10
79
80
81
82
83
84
year

Fig. 6d.

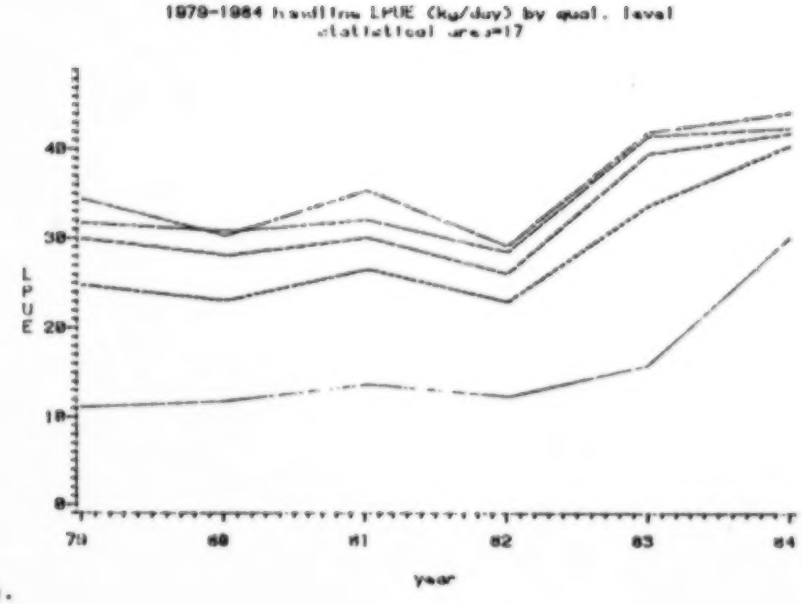
1979-1984 handline LPUE (kg/day) by qual. level
statistical area=17
LPUE
40
30
20
10
0
79
80
81
82
83
84
year

Fig. 6e.

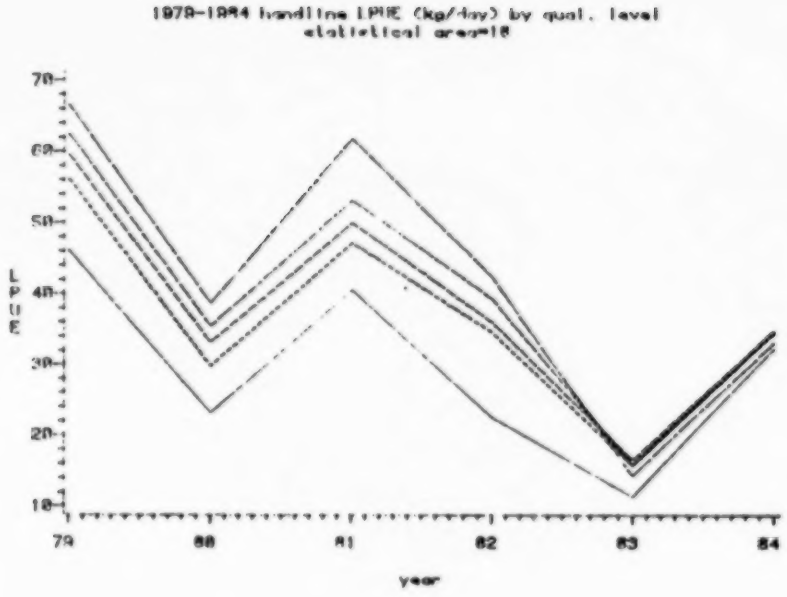
1979-1984 handline LPUE (kg/4hr) by qual. level
statistical area=18
70
60
50
40
30
20
10
LPUE
79
80
81
82
83
84
year

Fig. 6f.

Fig. 7a.

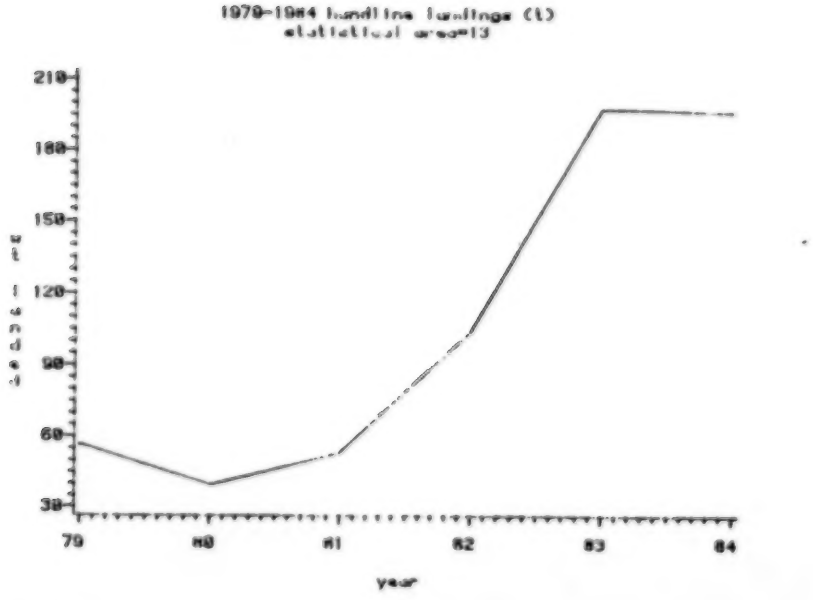

Fig. 7b.

Fig. 7a-7f. Handline/troll landings of rockfish (t) in statistical areas 12, 13, 15, 16, 17, and 18 as reported in the sales slip files from 1979 to 1984.

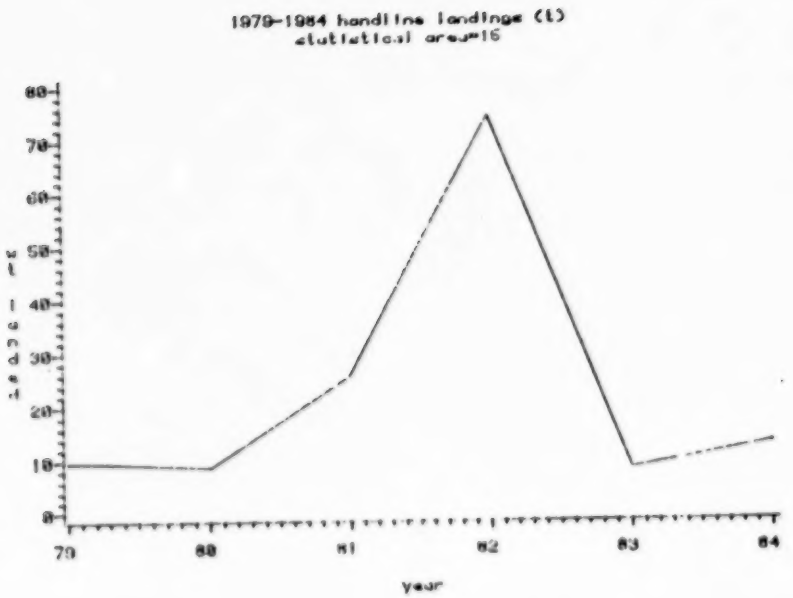
1979-1984 handline landings (t)
statistical area=16
80
70
60
50
40
30
20
10
0
79
80
81
82
83
84
year

Fig. 7c.

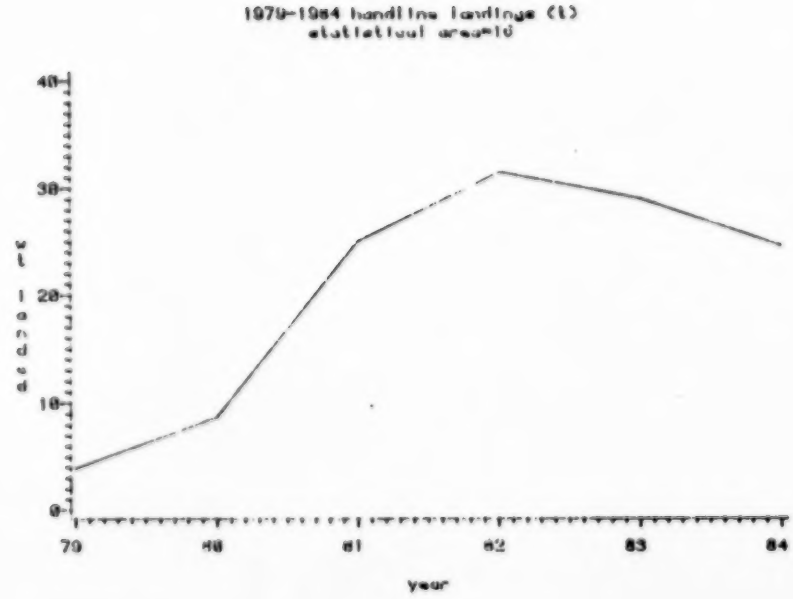
1979-1984 handline landings (t)
statistical area=10
40
30
20
10
0
79
80
81
82
83
84
year

Fig. 7d.

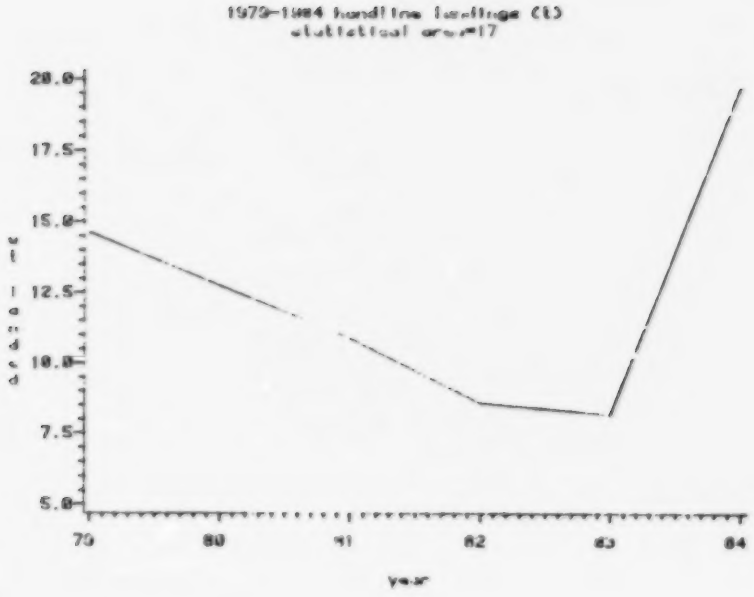
1979-1984 handline landings (t)
statistical area=17
20.0
17.5
15.0
12.5
10.0
7.5
5.0
79
80
81
82
83
84
year

Fig. 7e.

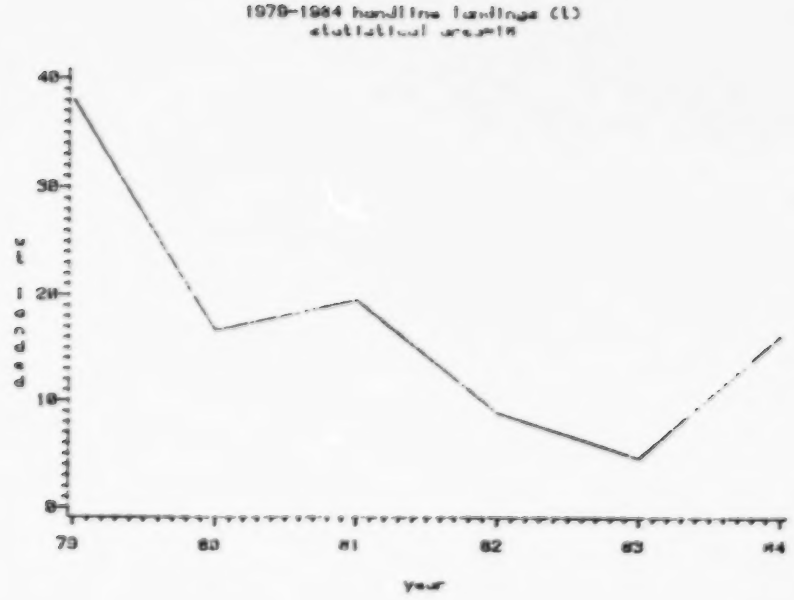
1979-1984 handline landings (t)
statistical area=18
40
30
20
10
0
79
80
81
82
83
84
year

Fig. 7f.

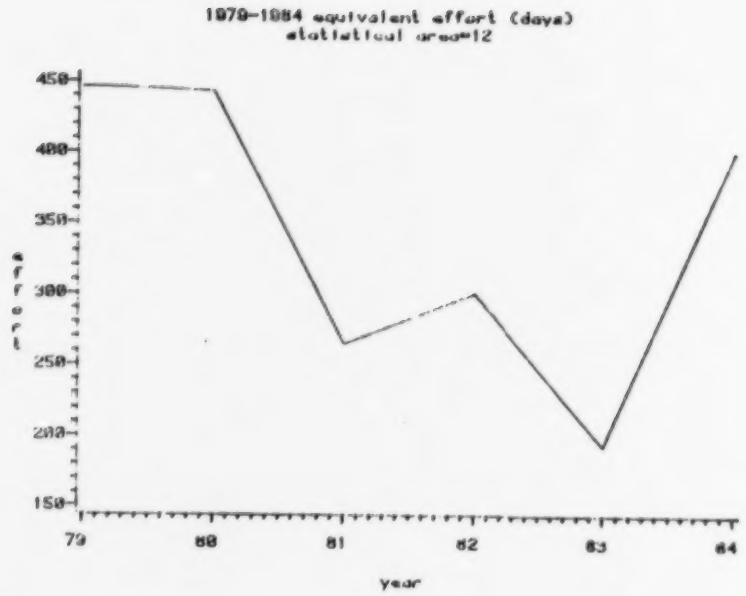

Fig. 8a.

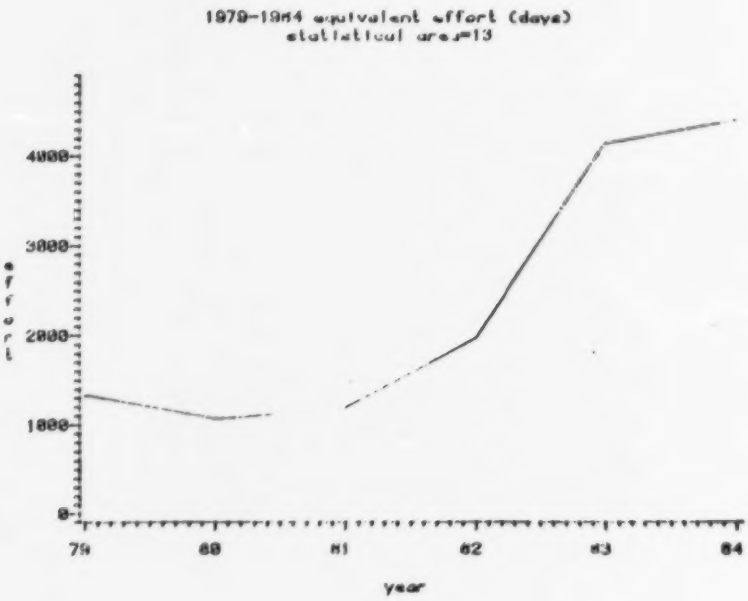

Fig. 8b.

Fig. 8a-8f. Handline/troll effort (days) on rockfish in statistical areas 12, 13, 15, 16, 17, and 18, from 1979 to 1984. Effort was calculated as the ratio of handline/troll landings of rockfish to 20% qualified LPUE.

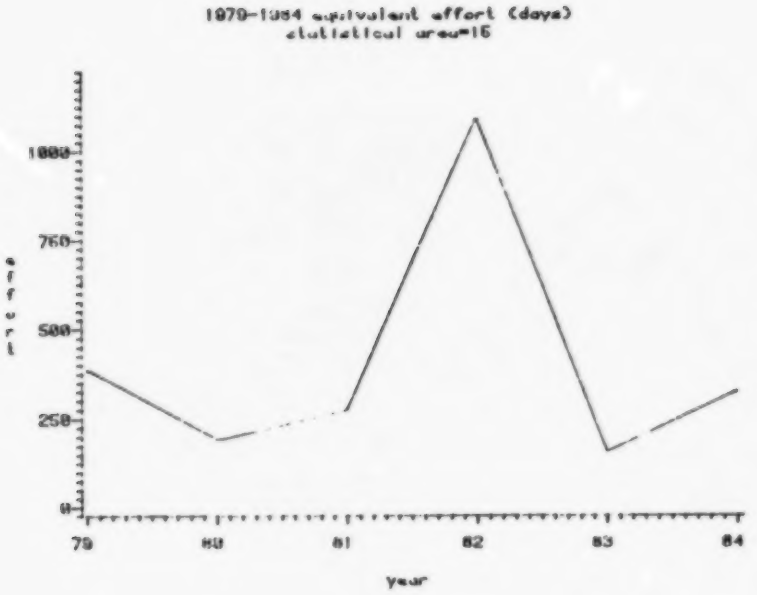
1979-1984 equivalent effort (days)
statistical area=16
1000
750
500
250
0
79
80
81
82
83
84
year

Fig. 8c.

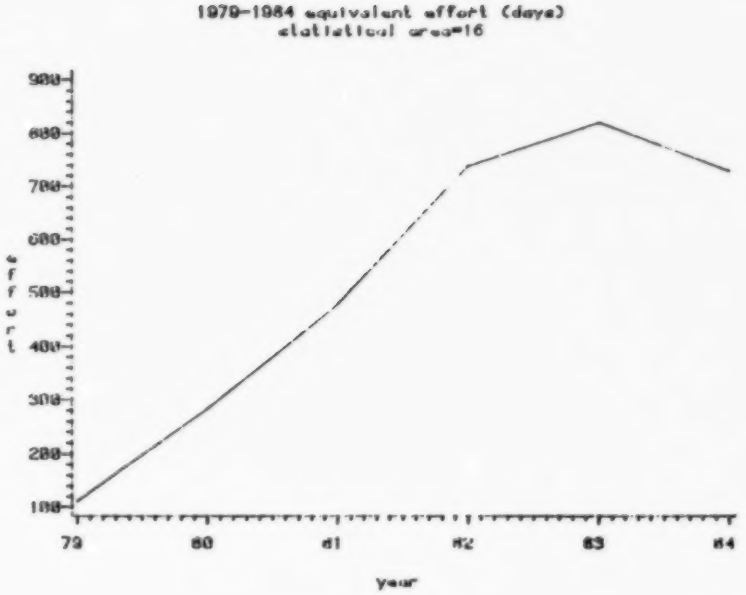
1979-1984 equivalent effort (days)
statistical area=16
900
800
700
600
500
400
300
200
100
79
80
81
82
83
84
year

Fig. 8d.

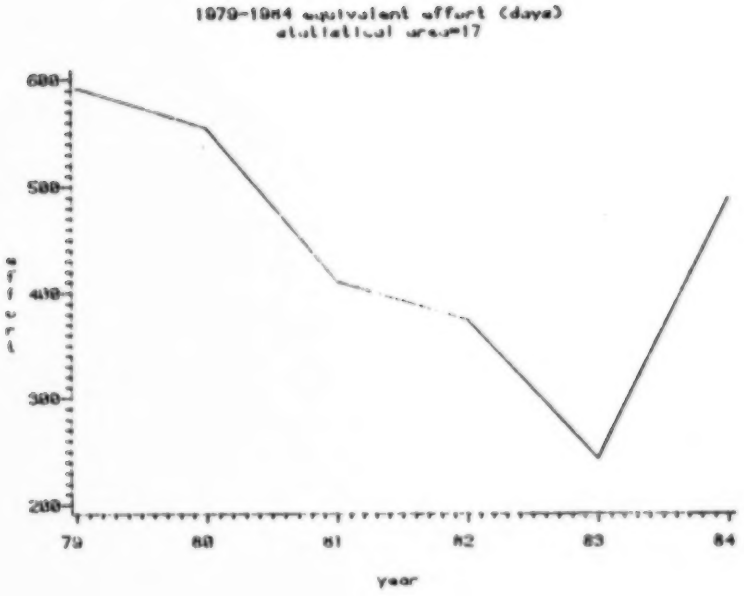
1979-1984 equivalent effort (days)
statistical area=17
600
500
400
300
200
79
80
81
82
83
84
year

Fig. 8e.

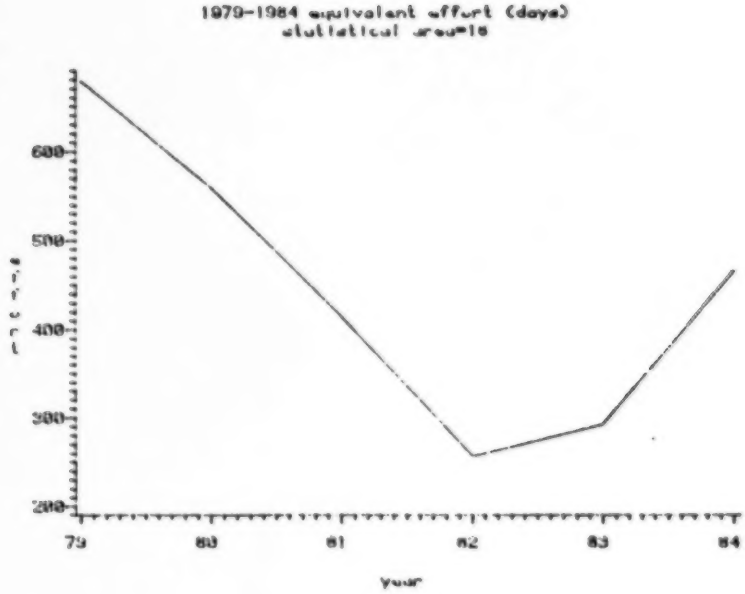
1979-1984 equivalent effort (days)
statistical area=18
600
500
400
300
200
79
80
81
82
83
84
year

Fig. 8f.